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Title: Broken Symmetry in the Pseudogap State of YBa2Cu3O6+x

Author(s): Ramshaw, Brad

Intended for: Discussion with external collaborators

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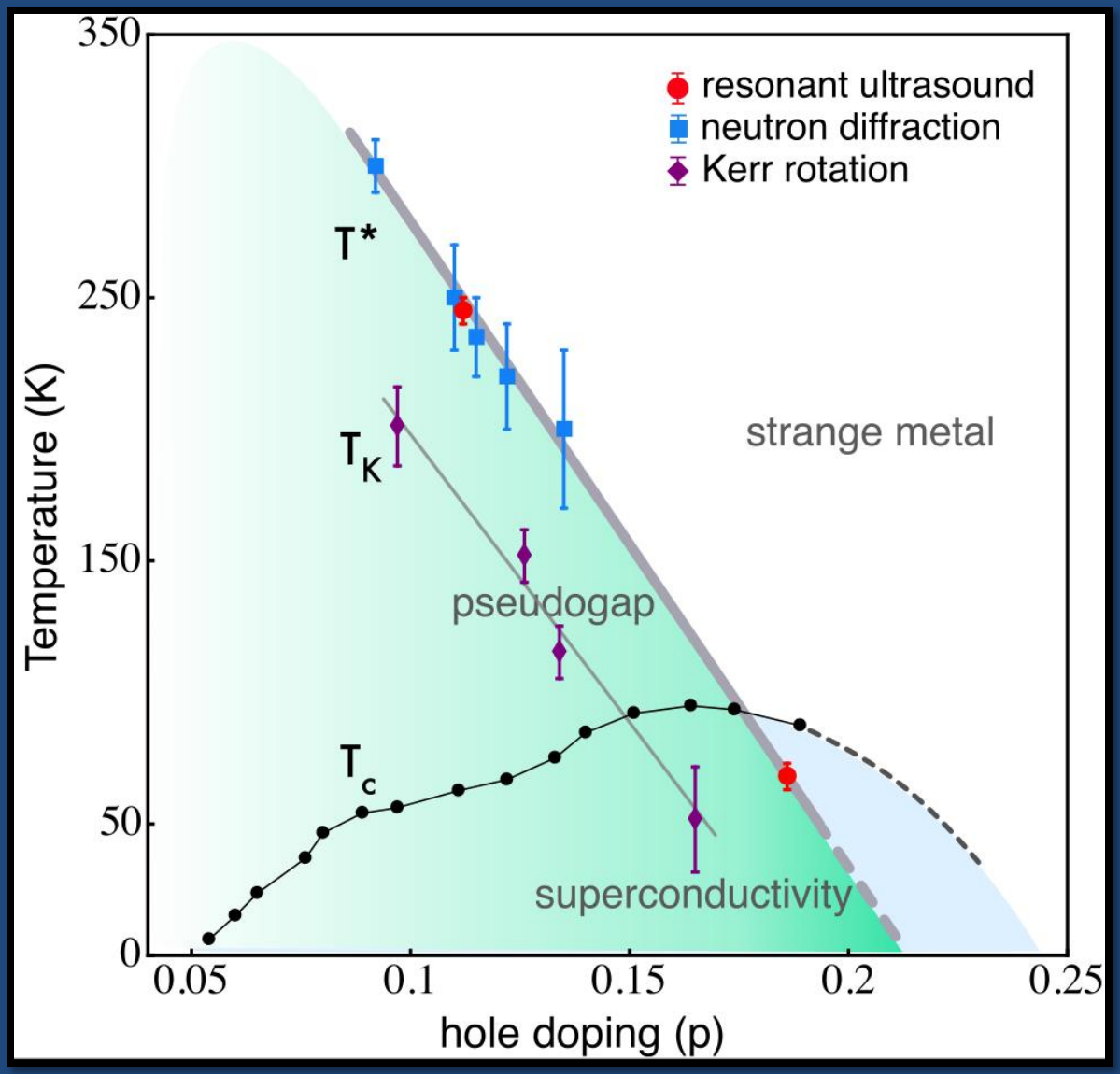
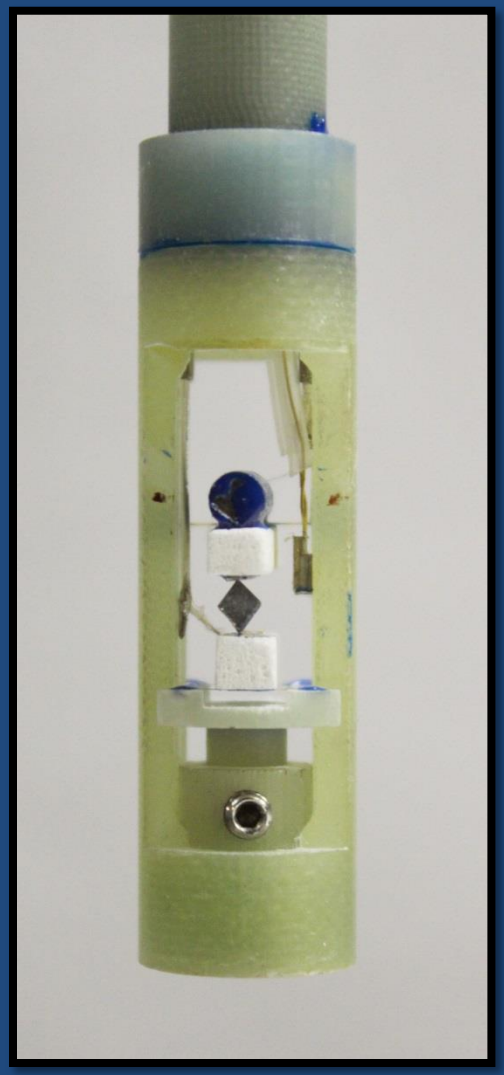
Broken Symmetry in the Pseudogap State of $YBa_2Cu_3O_{6+x}$

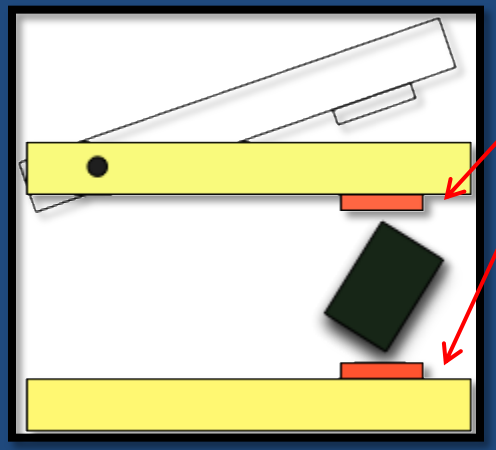
Brad Ramshaw

Pseudogap in $YBa_2Cu_3O_{6+x}$



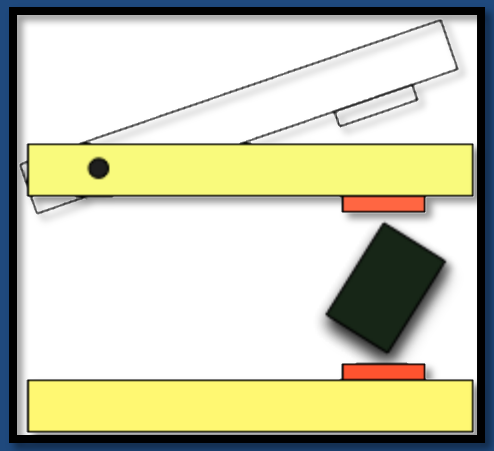
Resonant Ultrasound Spectroscopy

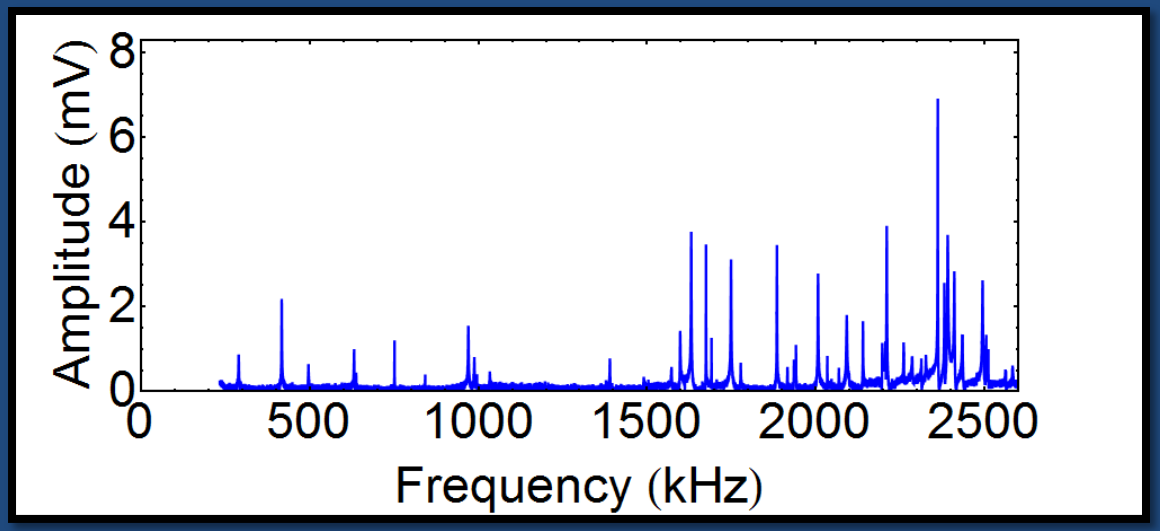


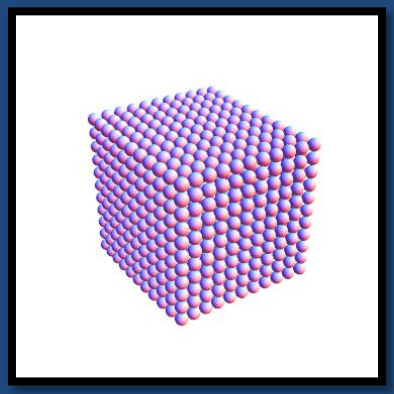


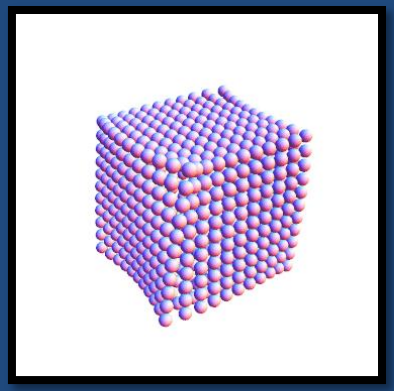
Drive at frequency ω
Detect transmitted power

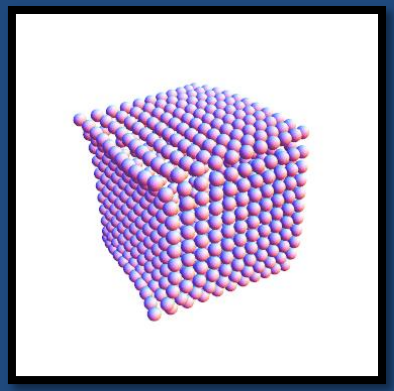
Resonant Ultrasound Spectroscopy

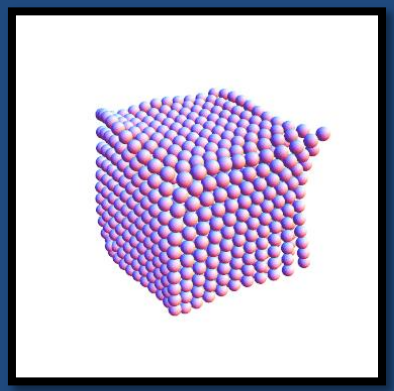






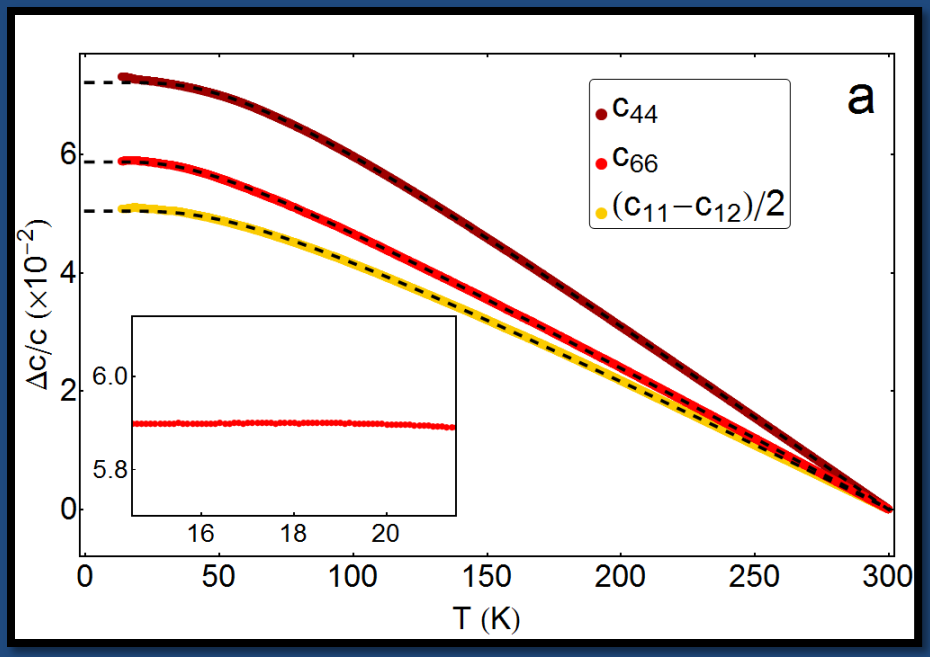




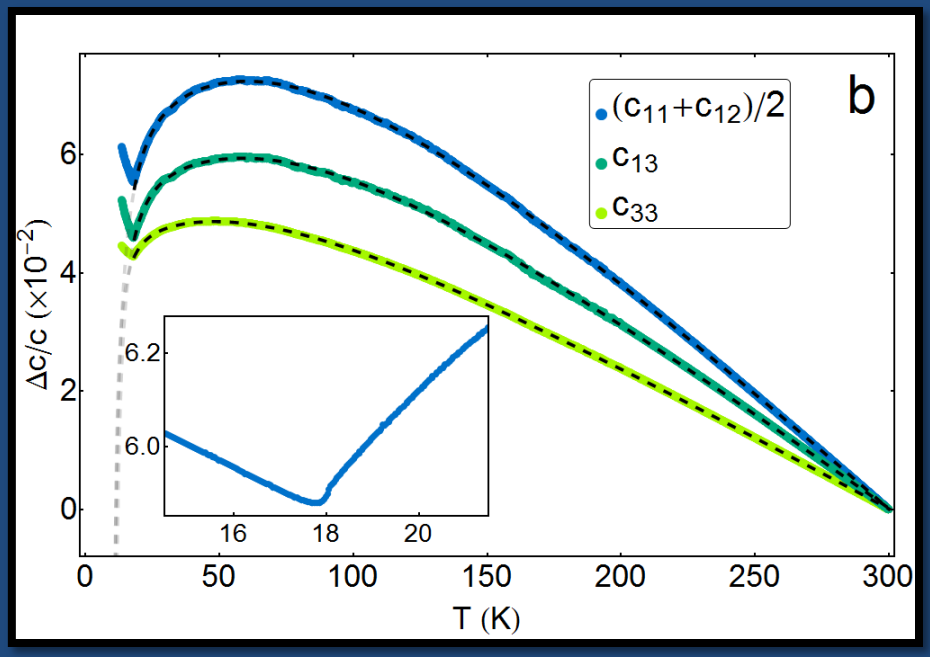


$PuCoGa_5$

Shear

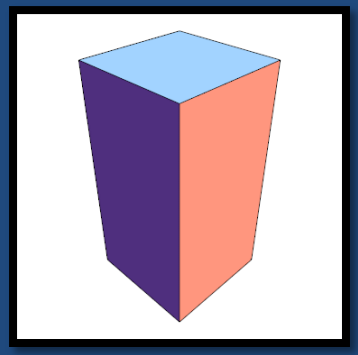


Compression



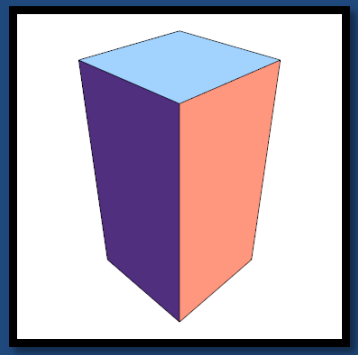
Strain in a Tetragonal Environment

Compressional



A_{1g}

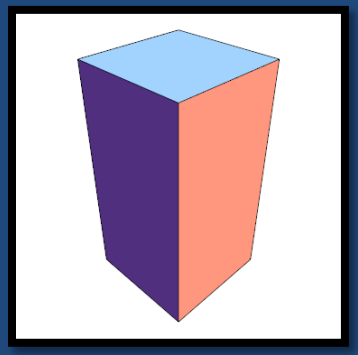
$(c_{11}+c_{12})/2$



A_{1g}

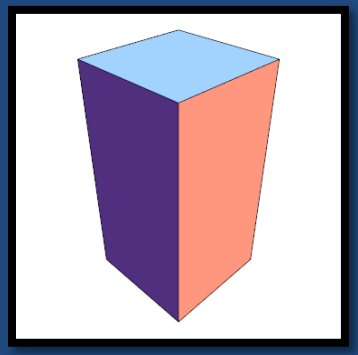
c_{33}

Shear



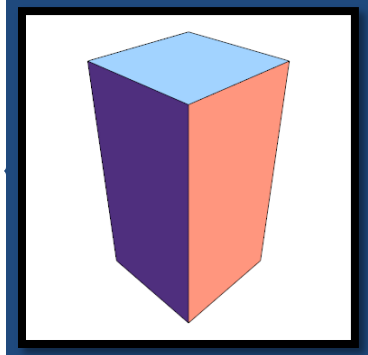
B_{1g}

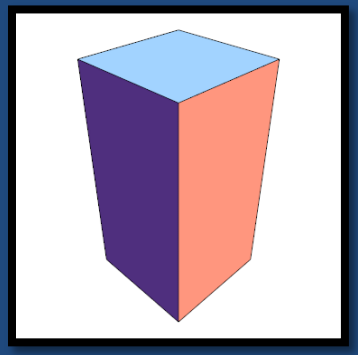
$(c_{11}-c_{12})/2$



B_{2g}

c_{66}

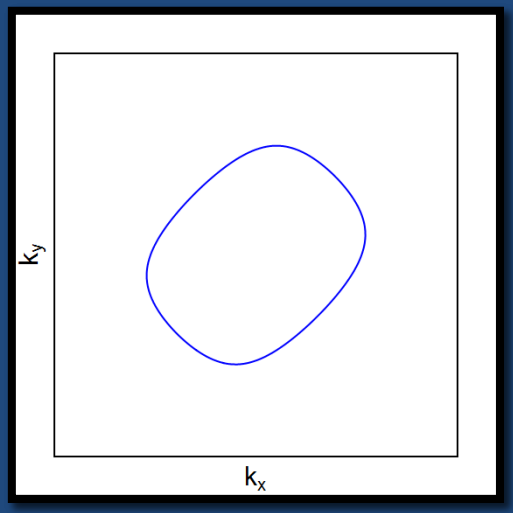


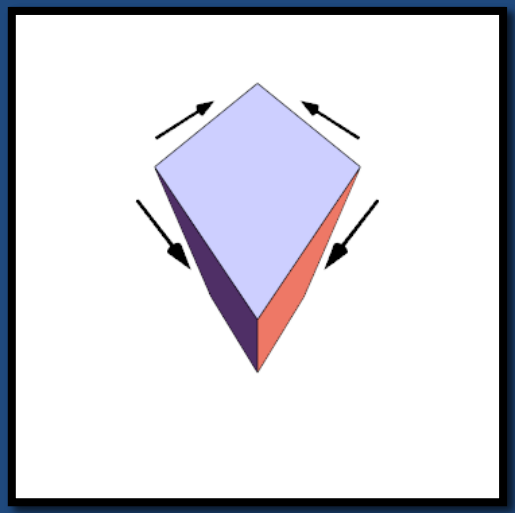


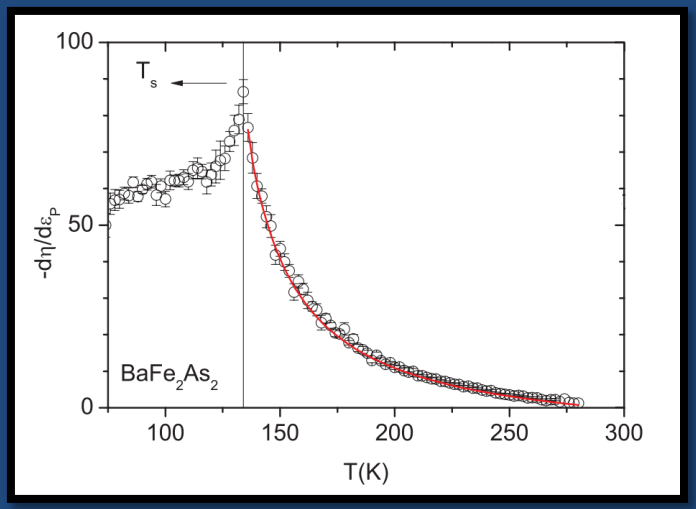
E_g

c_{44}

Order Parameter Coupling







Jiun-Haw Chu *et al.* Science 337, 710 (2012)

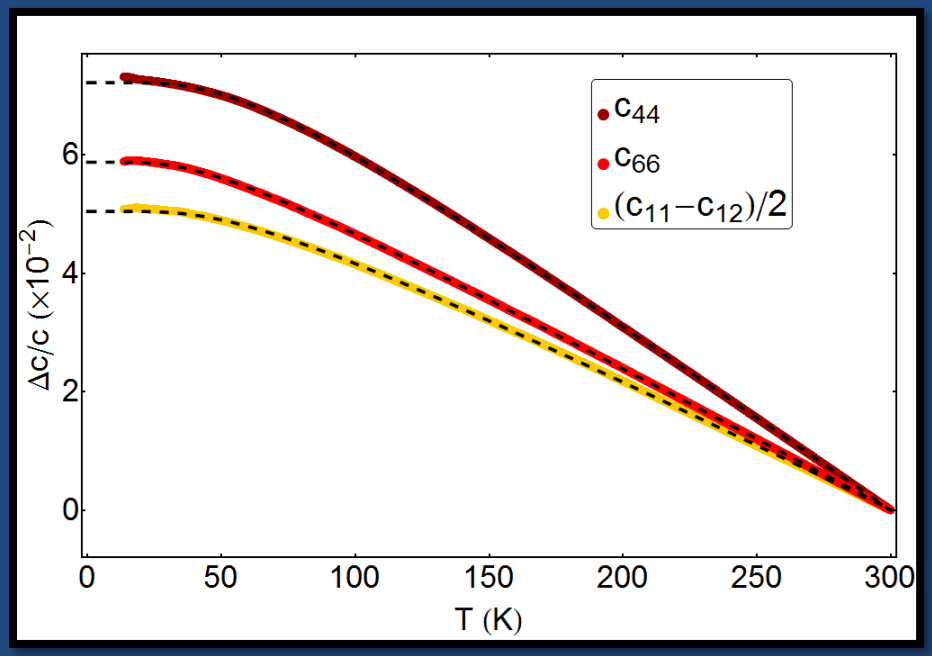
$$c_i = \frac{\partial^2 F}{\partial \varepsilon_i^{\,2}}$$

$$F = \sum_i c_i(\varepsilon_i)^2 + \alpha(T - T_0)\eta^2 + \beta(\varepsilon_{B2g} \cdot \eta) + \ldots$$

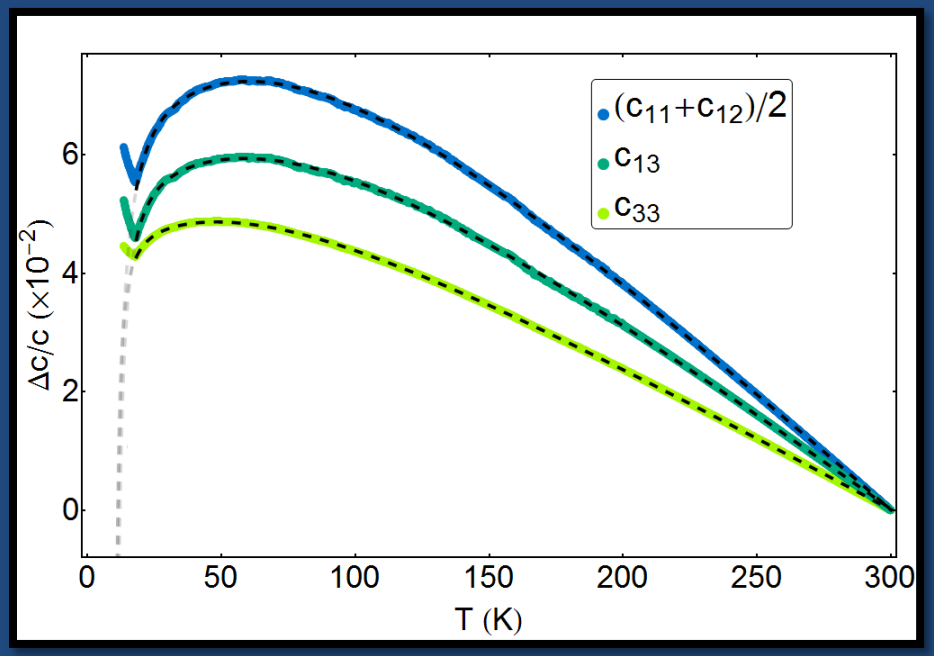
$$c_{B2g} \propto \frac{1}{T - T_0}$$

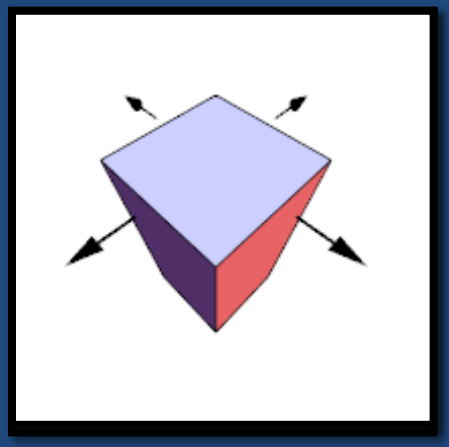
Valence Fluctuations in $PuCoGa_5$

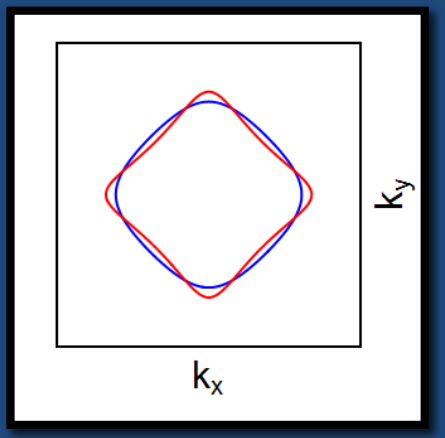
Shear



Compression

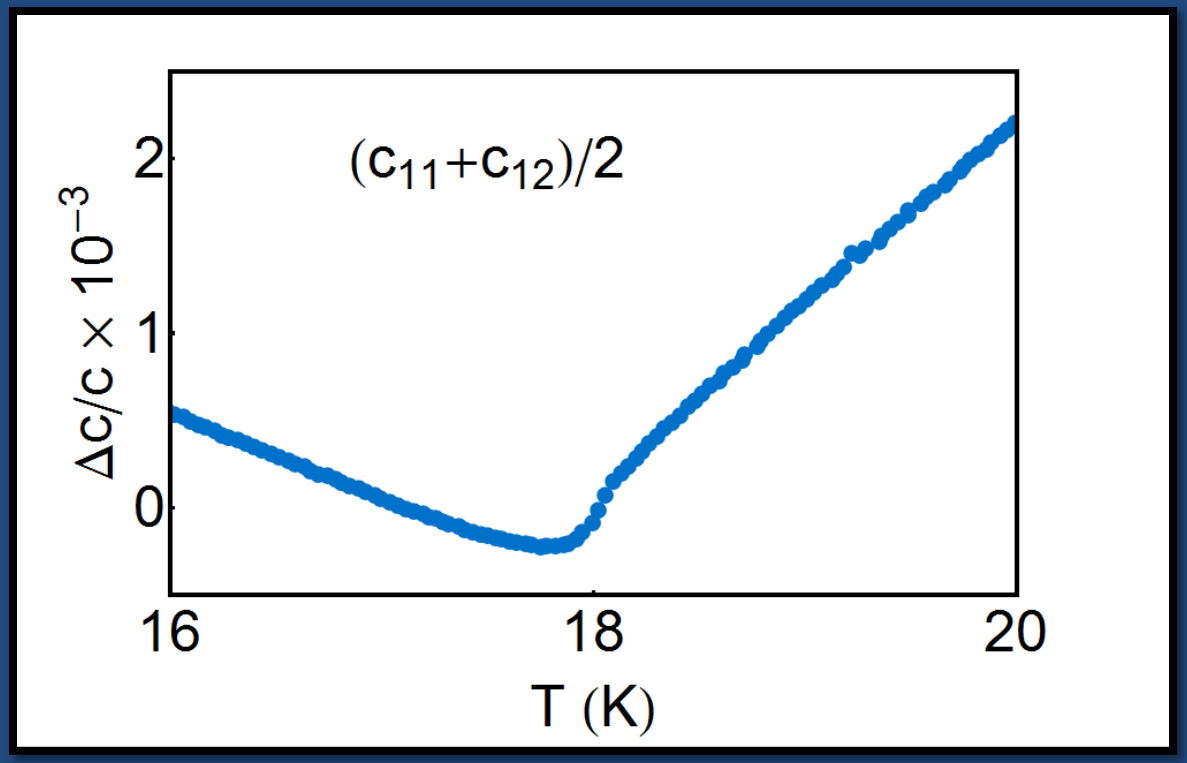






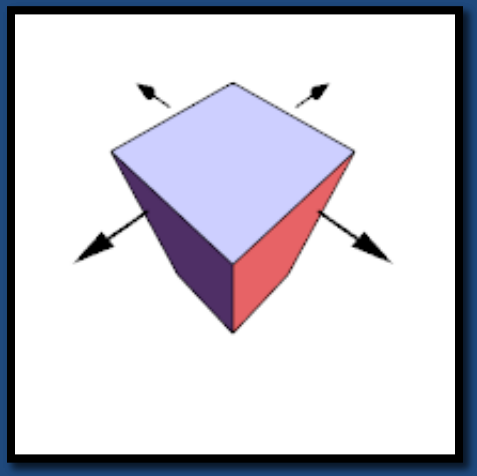
Superconductivity in $PuCoGa_5$

$$F = \sum_i c_i(\varepsilon_i)^2 + \alpha(T - T_c)|\psi|^2 + \gamma|\psi|^4 + \beta(\varepsilon_{A1g} \cdot |\psi|^2) + \ldots$$

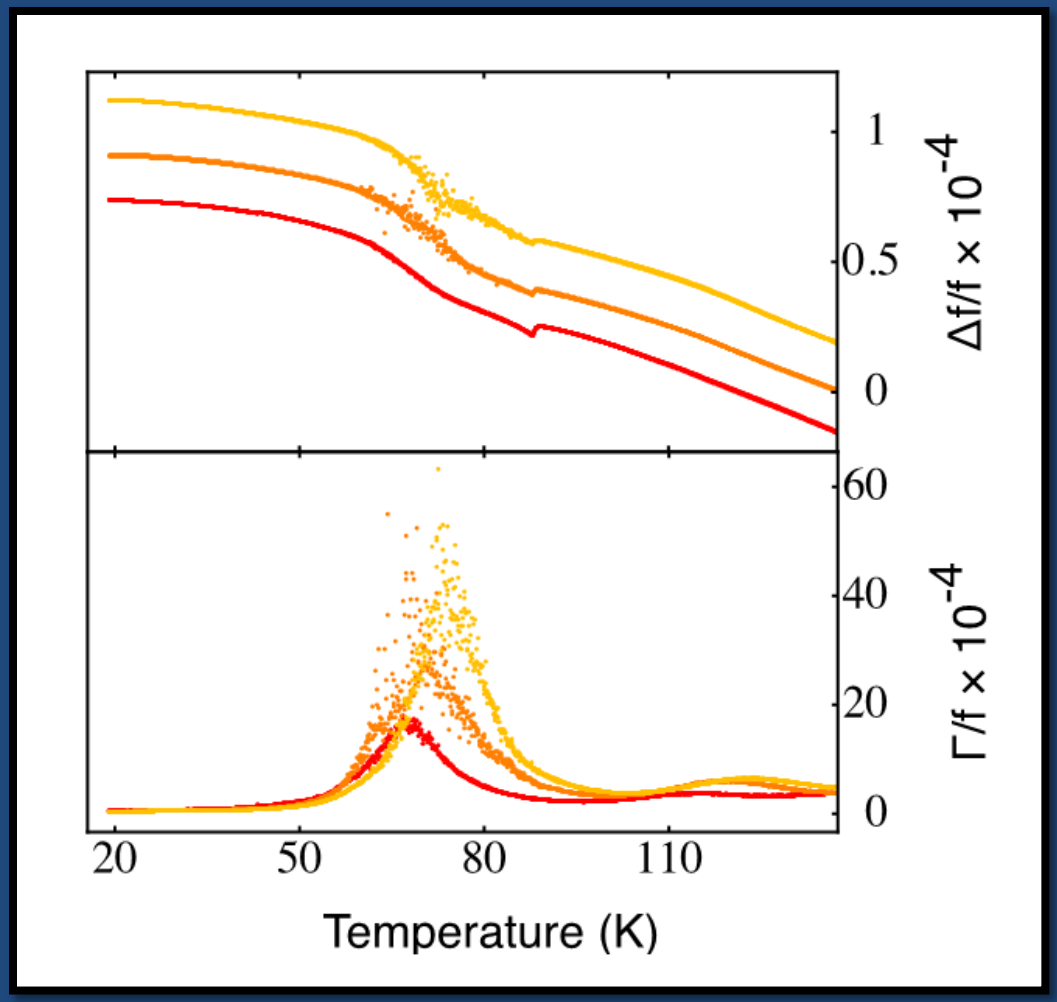


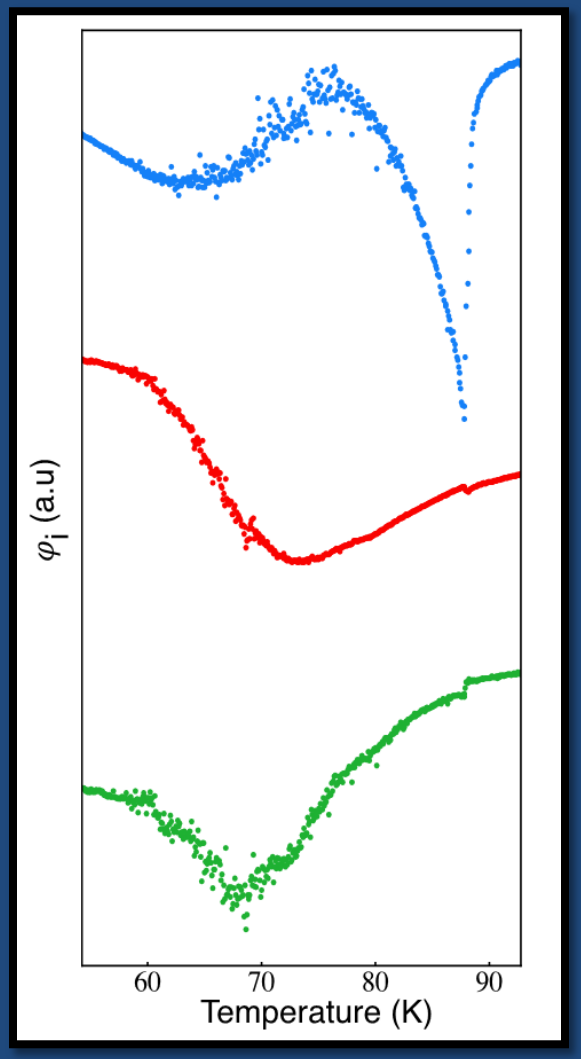
$$c_{A1g} = c^0_{A1g} \qquad T > T_c$$

$$= c^0_{A1g} - \frac{\beta^2}{2\gamma} \qquad T < T_c$$

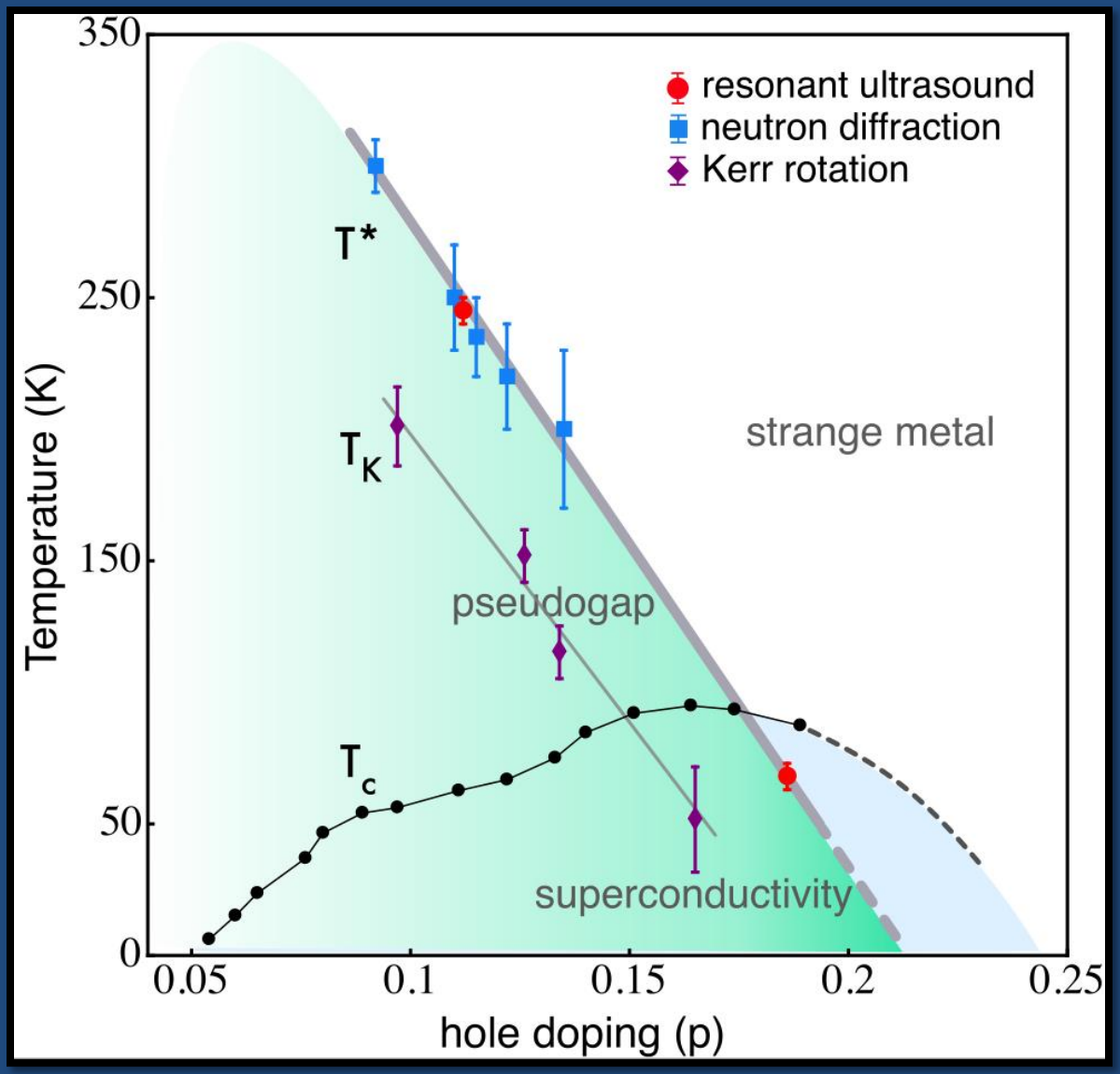


Discontinuity at the Pseudogap in $YBa_2Cu_3O_{6+x}$

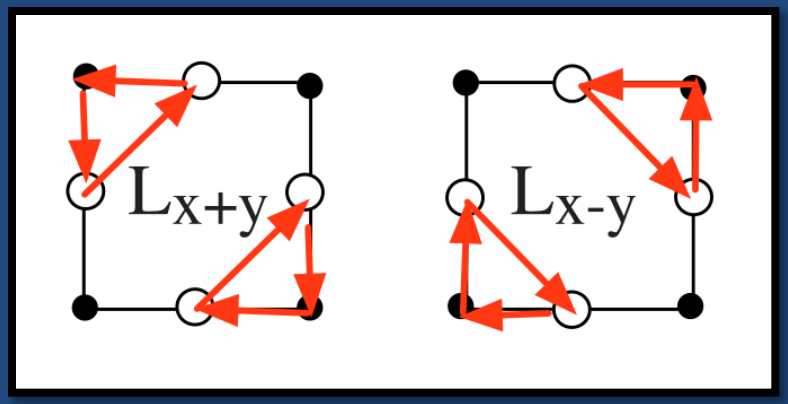




Pseudogap in $YBa_2Cu_3O_{6+x}$



Scenarios for the Order Parameter



Shekhter, A. *et al.* PRB 80, 214501 (2009)

$$E_u \times E_u \rightarrow A_{1g} + A_{2g} + B_{1g} + B_{2g}$$

$$(c_{11}+c_{12})/2 \qquad (c_{11}-c_{12})/2 \qquad c_{66}$$

$$c_{33}$$

All four moduli should show a discontinuity at T*!

Summary